9835-A AND 9835-B
STABILIZED D-C MICROVOLT AMPLIFIERS

NOT FOR PRODUCTION

AS-277
METROLOGY
LABORATORY

LEEDS & NORTHRUP

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9835-A AND 9835-B

STABILIZED D-C MICROVOLT AMPLIFIERS

1. GENERAL DESCRIPTION

This instruction book applies to the 9835-A and 9835-B Stabilized D-C Microvolt Amplifiers. A photograph of the No. 9835-B is shown in Fig. 1. The No. 9835-A appears exactly the same except it has a zero-left indicating meter rather than a zero-center meter.

Fig. 1

Being completely self-contained, null balance type instruments, these microvolt amplifiers can be used as calibrated deflection-type indicators, as highly versatile null detectors, or as preamplifiers for potentiometer-type recorders or other devices which meet resistance and range requirements.

(1) As indicators, these amplifiers are suitable for directly measuring voltage output of thermopiles, thermocouples, strain gage bridges, bolometer bridges, and similar primary elements and transducers having relatively low internal resistance and low output. In addition, small currents originating in high resistance sources may be measured in terms of microvolts drop across a series resistor.

(2) As preamplifiers in combination with Speedomax® G recorders or auxiliary, manually-balanced potentiometers, all of the preceding measurements may be made with increased overall accuracy over long or short test periods.

(3) As null detectors, the 9835 type instruments are equal to the extra high voltage-sensitivity galvanometers used in low resistance circuits, and much better when used in higher resistance circuits.

2. SPECIFICATIONS

The specifications listed below apply to both the 9835-A and the 9835-B except where noted otherwise.

Type . . . . . Low level d-c voltage amplifier

Ranges 9835-A 9835-B

Range Switch	Zero-Left Meter	Zero-Center Meter
50 μv	0 to 50 μv	−25 to 0 to +25 μv
100 μv	0 to 100 μv	−50 to 0 to +50 μv
200 μv	0 to 200 μv	−100 to 0 to +100 μv
500 μv	0 to 500 μv	−250 to 0 to +250 μv
1000 μv	0 to 1000 μv	−500 to 0 to +500 μv
2000 μv	0 to 2000 μv	−1000 to 0 to +1000 μv

Limit of error . . . . . (a) of amplifier response: ±0.4% of range span

(b) of meter readings: add 1% to (a)

(c) of zero: maximum offset ±0.5 microvolt within which drift will not exceed 0.2 microvolt during any 1 minute interval, after warm-up.

Meter sensitivity . . . . . ±0.5% of scale span (limit determined by meter)

Response time . . . . . Approximate values to within 1% of balance:

(a) 2 seconds for 2000 ohms maximum source resistance

(b) 3 seconds for 10000 ohms maximum source resistance

Source resistance . . . . . 10000 ohms, maximum

Equivalent noise level . . . . Less than 0.15 μv

Amplifier input impedance . (a) Steady-state conditions—approximately 12 megohms

(b) Transient conditions—can be represented approximately as 12 megohms resistance shunted by 220 microfarads of capacitance and this combination in series with 2000 ohms.

Amplifier output . . . . . 9835-A, as Indicator:

(a) Linear response—full scale meter deflection occurs for normal full scale input of range used.

(b) Non-linear response—40 times the normal full scale input required to cause approximately 1/2 scale deflection. Approximately 1/3 full sensitivity retained at zero.

9835-A, as Preamplifier:

(a) RECORDER connector (terminals #1 and #2)—10 millivolts maximum across 500 ohms, corresponding to any selected input range. For use with potentiometer null-balance indicators or recorders only.

(b) RECORDER connector (terminals #1 and #3)—1 volt maximum, corresponding to any selected input range. For use with devices having internal resistance of 20000 ohms or greater.

9835-B, as Indicator:

(a) Linear response—full scale meter deflection occurs for normal full scale input of range used.

(b) Non-linear—80 times normal positive or negative full scale input required to cause approximately full scale positive or negative deflection. Approximately 1/3 full sensitivity retained at zero.

9835-B, as Preamplifier:

(a) RECORDER connector (terminals #1 and #2)—±5 millivolts maximum across 500

ohms, corresponding to any selected input range. For use with potentiometer null-balance indicator or recorder only.

(b) RECORDER connector (terminals #1 and #3)—±0.5 volt maximum corresponding to any selected input range. For use with devices having internal resistance of 20000 ohms or greater.

Switches . . . . . Six-position range switch:

Ranges: 50, 100, 200, 500, 1000, and 2000 microvolts

Three-position operation switch:

(1) Indicator—NON-LINEAR meter response

(2) Indicator—LINEAR meter response

(3) Preamplifier—output to RECORDER connector

ON-OFF line power switch

Meter* . . . . . 9835-A, zero-left meter movement
9835-B, zero-center meter movement

NOTE: The inside of the lucite meter face has been treated with an anti-static film. The lucite face should not be removed from the meter.

Ground connections . . . . . The amplifier chassis and shielding are normally insulated from the instrument case and panel thus forming a floating circuit ground. SHIELD binding posts are provided to physically ground the chassis and shielding, where necessary.

Power supply . . . . . 120 volt, 50/60 cycles, approximately 40 volt-amperes

Case . . . . . Metal: 10-3/4" high x 19-3/8" wide (exclusive of handles) x 8-3/4" deep

Weight . . . . . 34 pounds, approximately

*NOTE: Zero-left meter (021023) can be interchanged with zero-center meter (021024).

Operating note . . . . . Consideration must be given to the nature of the network producing the unknown emf, since (as a result of thermal agitation, thermal-electric potentials, insulation leakage currents, stray capacitance currents, etc.) spurious potentials may easily equal or exceed the magnitude of the unknown voltage.

3. THEORY OF OPERATION

A block diagram of the instrument is shown in Fig. 2.

A high gain (10^7), low level (10^{-11} ampere), 50/60 cycle amplifier is the heart of the instrument. The low input level is made possible by the use of high d-c feedback, careful magnetic and electrostatic shielding, special precautions to minimize and to balance stray thermal emf's, and the use of d-c on all low level tube filaments. Standard tubes are used throughout; however, the first stage tube is replaced during assembly if it is noted as being highly microphonic. The user should do likewise.

Conversion from direct to alternating current by means of a contact-type synchronous converter avoids the conventional d-c amplifier and its inherent zero drift. The synchronous reconversion to direct current permits the use of over-all d-c feed-back to stabilize the gain. By proper attention to the transmission versus frequency characteristic of the feed-back loop, the amplification of the a-c amplifier has been increased, without causing oscillation, to the point where the steady-state instrument reading is dependent almost entirely upon the direct voltage to be measured (and the value of the precision attenuator in the feed-back loop, i.e., the setting of the range dial) and only to a negligible extent upon other factors.

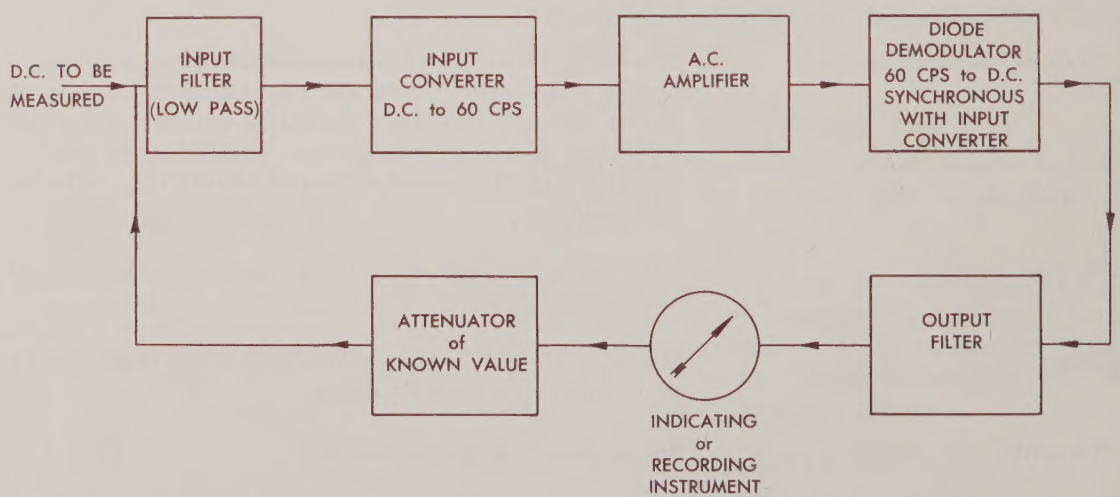

D.C. TO BE MEASURED
INPUT FILTER (LOW PASS)
INPUT CONVERTER D.C. to 60 CPS
A.C. AMPLIFIER
DIODE DEMODULATOR 60 CPS to D.C. SYNCHRONOUS WITH INPUT CONVERTER
ATTENUATOR of KNOWN VALUE
INDICATING or RECORDING INSTRUMENT
OUTPUT FILTER

Fig. 2—Block Diagram of 9835 Microvolt Amplifier.

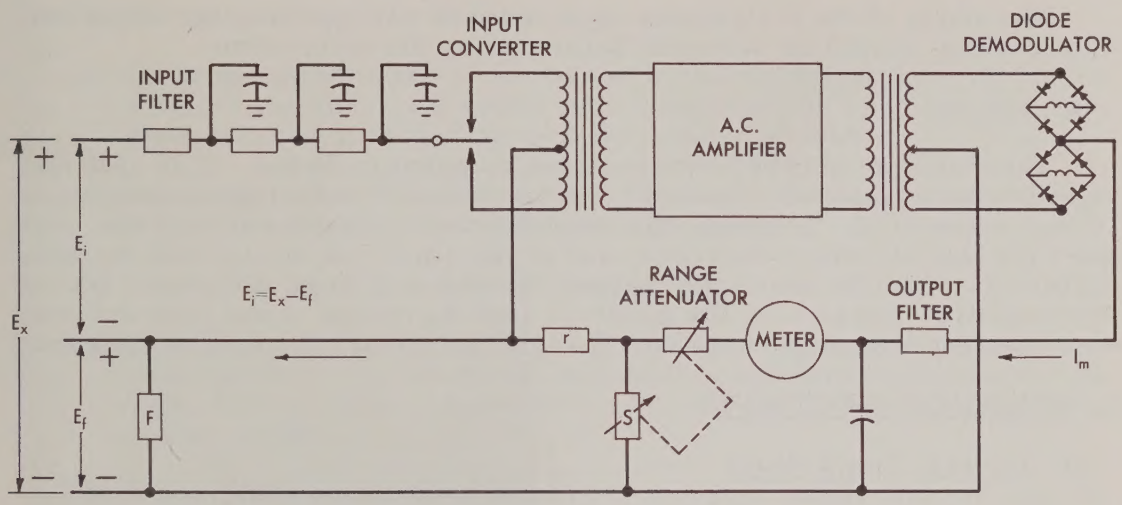


Fig. 3—Simplified Instrument Circuit Illustrating Series Type Feedback.

The low pass filter on the input attenuates frequencies above the response band of the system and so avoids overloading of the amplifier.

Fig. 3 shows in simplified form the series type of feed-back which is used.

Because of the high gain of the amplifier, the current into the input converter circuit is so small that the d-c voltage drop (e_I) across the input filter and converter is negligible and the voltage (e_F) across the feedback resistor F nearly equals the input voltage (e_X) being measured. The small voltage drop e_I indicates only a small current through the input circuit—small enough to maintain practically an open-circuit condition across the circuit being measured. This is essential for null potential measurements.

With zero attenuation in the range attenuator (S = infinity), $I_M = e_X/F$ to a high degree of accuracy. For an attenuator setting other than zero, $I_M = e_X (S + F + r)/SF$. Thus the meter reading is proportional to the input voltage e_X to a high degree of accuracy inasmuch as the attenuator and feed-back resistors are stable high precision resistors.

4. PREPARE AMPLIFIER FOR SERVICE

4A. Unpack

The amplifier is shipped with all plug-in components in place.

Remove and discard the two round head shipping bolts in the bottom of the case.

The inside of the instrument case is filled with packing for shipment. This packing should be removed before using the instrument.

4B. Mount

The amplifier may be bench mounted or panel mounted. It is also designed so that it may be removed from its case and mounted on a standard 19 inch relay rack. To mount the amplifier on a panel or relay rack, remove the four screws on the front panel of the amplifier which hold the amplifier chassis in the case, and remove the chassis from the case. Mount the amplifier chassis on the panel or rack by means of the four screws, which were previously removed. It is not necessary to replace the case.

5. WIRING CONNECTIONS

5A. Internal Connections

The internal wiring connections are shown in schematic form in Fig. 5. The amplifier chassis is insulated from the panel and case for above-ground measurements. It must be realized that all insulated connectors and switches extending through the front panel are at the same potential as the chassis and one side of the amplifier, and will not be at ground potential when above-ground measurements are made. The SHIELD posts permit grounding the chassis. A screw terminal on the back of the case permits grounding the panel and case, which can also be grounded through a third conductor in the power cable.

5B. Power Supply

A plug and cord is attached to the amplifier to connect it to a 120 volt 50 or 60 cycle power source. Approximate consumption is 40 va.

5C. Input Connector

A special input connector for the INPUT receptacles is furnished with this instrument. The connector (L&N 37-2-0-9) is identified by its gold-plated contacts and the green and white twisted copper leads connected to it. This twisted pair is designed for use with this instrument and is soldered to the connector with a special solder having a low thermal emf against copper. Therefore, the use of these leads is recommended, and it is important that no ordinary solder be used which may create excessive thermals at the contacts.

All of those soldered connections within the amplifier which are made with the special solder are painted with green lacquer.

External soldered connections to the input leads should be made with the special solder furnished with the instrument. In this way thermals, which create a zero-offset, are reduced. Contamination by ordinary solders will cause thermals. Additional thermal free solder may be ordered from Leeds & Northrup Company as Part No. 107-1-0-1.

Soldering technique for thermal free solder:

(1) Of prime importance is the use of a new soldering iron tip tinned with the thermal free solder which must not be used for any purpose other than soldering with thermal free solder.

(2) Surfaces to be joined must be clean and must not be tinned with any material other than thermal free solder.

(3) Rosin flux should be used in making the joints.

(4) It is generally necessary to run the soldering iron a little cooler than normal. For example, at Leeds & Northrup Company a 100 watt, 115 volt iron is operated on 80 volts in order to obtain optimum results.

(5) It has been found that satisfactory joints made with the special solder lack the bright smooth appearance obtained with regular solder. They look somewhat like a cold joint but are perfectly satisfactory, both mechanically and electrically.

Instructions contained in Section 5E should be observed in making the input connections.

5D. Output Connector

The RECORDER receptacle and a three pin plug are provided for connecting the amplifier output to a recorder or other external circuit.

Refer to Amplifier Output under Specification, Section 2, to determine which pins of the output plug to use in making the output connections.

To connect the amplifier output to the RECORDER receptacle, set the operation selector switch to the RECORDER position.

5E. Polarity

Input pin #1 and output pin #1 are the common low-impedance terminals. The low-impedance side of the source is to be connected to input pin #1, regardless of polarity.

Standard*: When input pin #1 is made positive with respect to input pin #2, the meter will deflect to the right. Output pin #1 will be the positive output terminal. A standard Speedomax recorder (having its low-impedance terminal positive) may be connected to the RECORDER receptacle.

* For all instruments having serial number higher than 1003290.

1. Set RANGE switch to give a suitable amplifier range.

Apply meter percentage reading to RANGE switch setting.

2. Set the operation selector switch to obtain desired type of operation.

3. Connect input plug at this receptacle or at INPUT receptacle on back panel.

Connect Speedomax instrument or other external indicator to RECORDER receptacle on back panel.

4. Adjust meter zero with adjusting screw on meter case with line switch off.

If desirable, ground the chassis by connecting the SHIELD terminal, also provided on back panel, to ground.

5. Connect the power cord to a 120 volt 50 or 60 cycle line. Snap the line switch on and allow the instrument to warm up. A slight meter deflection may occur. Short out the input and note the magnitude of this zero offset, for which compensation can be made by using it as a correction factor or by readjusting the meter zero.

Fig. 4

Reversed: When input pin #1 is made negative with respect to input pin #2, a zero-left meter will be forced against its zero stop and a zero-center meter will deflect to the left. The zero-left meter must be reversed by interchanging the yellow and red leads on the rear of the meter. The zero-center meter may be reversed if desired. A zero-left recorder must be reversed by reversing the connections to its dry cell, standard cell, and control winding of the balancing motor. A zero-center recorder may be reversed by the same means, if desired.

5F. The Demodulator

The a-c to d-c converter, X2, is an electronic diode-demodulator.

The diode demodulator consists of two diode-bridge networks and a switching-voltage transformer. The bridge networks conduct current between terminals 1 and 2 or 1 and 4 respectively, only during one-half cycle of their individual sixty-cycle switching voltage. The switching voltage secondaries are so connected as to operate the networks 180 degrees out of phase with each other. Therefore, the diode-bridge networks

resemble two switches, closed on alternate half cycles of the switching voltage. The phase of the switching voltage relative to the line voltage is determined by the resistor and capacitor in the primary circuit of the transformer. The demodulator operates in synchronism with the input converter, allowing for the phase shift of the signal in the a-c amplifier.

6. OPERATION

Typical operating procedures are given in Fig. 4.

7. MAINTENANCE

The only maintenance normally necessary is the eventual replacement of weak or defective tubes.

If the amplifier does not perform properly, it is suggested that the tubes be tested and weak tubes replaced. When a tube must be replaced, any tube of the same type and quality may be used. However, it is preferable to order a tube which has received a more complete quality check from Leeds & Northrup Co. If the tubes check satisfactorily or if new tubes do not remedy the faulty operation, it is suggested that the Leeds & Northrup Company be contacted. In the initial correspondence, give the catalog number and the serial number which are on the front panel or stamped on the top of instrument chassis.

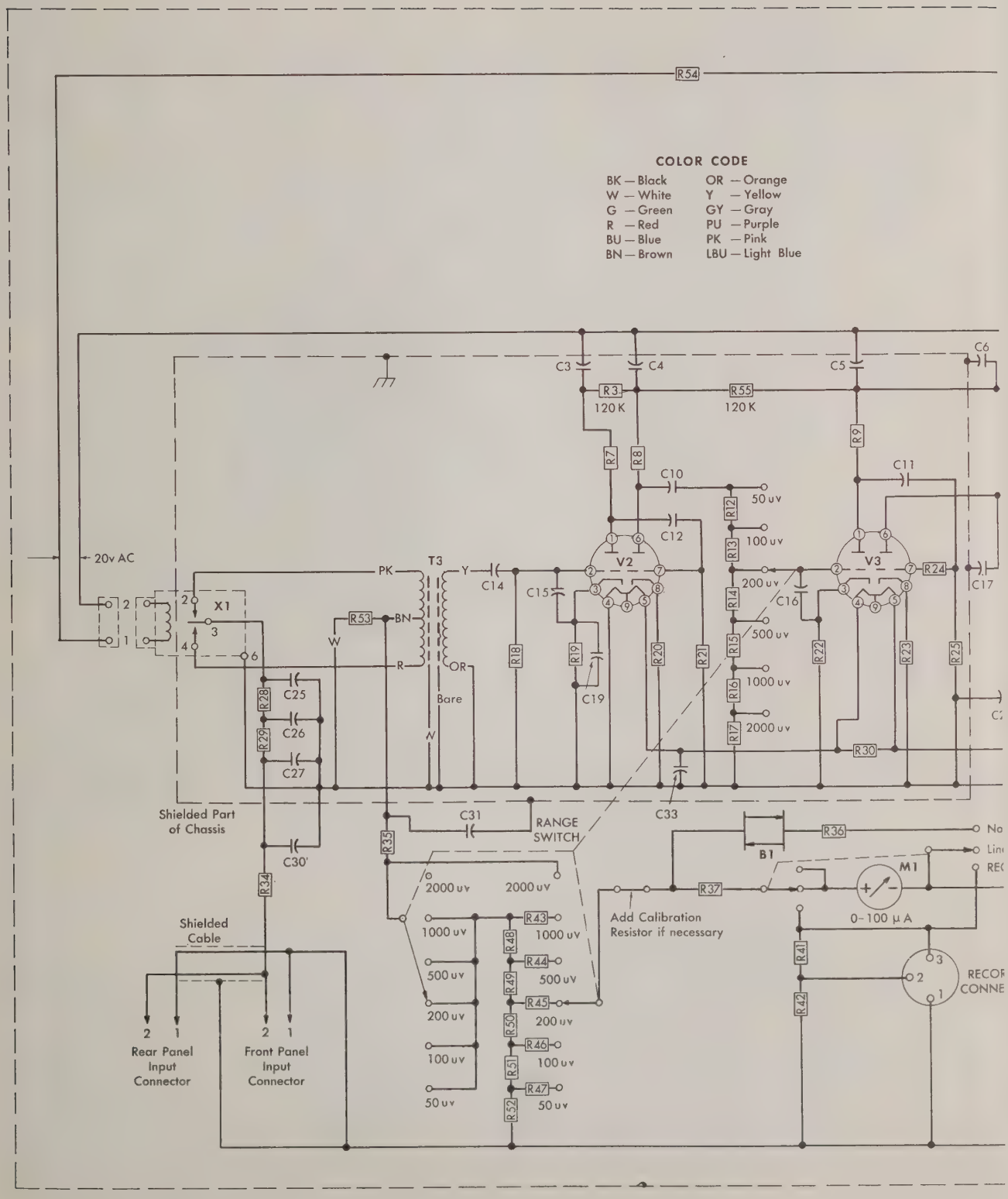
It may become necessary when servicing the instrument, to check for defects in the diode demodulator. By making simple d-c resistance measurements between pins, it is possible to detect and identify a defective component without removing the demodulator case.

Using a Simpson Model 260 or equivalent 20,000 ohms-per-volt meter, make the measurements indicated below.

Pins	Nominal Resistance
6 to case	zero
7 to 8	2000 ohms
1 to 7	infinite
1 to 6	infinite
7 to 6	infinite

Measure the resistance between pins 1 and 2 and between pins 1 and 4; then reverse the meter leads and again measure the resistance between these pins. The resistance for both the forward and reverse measurements should be 50K. By noting the results of these sets of forward and reverse resistance measurements, the presence of a defective component can be detected and the type of failure determined from the following table. Further analysis of the circuit and test results will readily trace the defect to a specific pair of diodes or resistors.

SYMPTOM	DEFECT
Both forward and reverse resistance either infinite or very high.	Open circuited transformer secondary or either 12K resistor.
Very high resistance in one direction and normal resistance in other direction.	Open circuited diode.
Low but unbalanced resistance in both directions. For example, 22K in one direction and 35K in other direction.	Short circuited diode.
Low but symmetrical resistance in both directions.	Either 12K resistor shorted.


COLOR CODE
BK — Black
W — White
G — Green
R — Red
BU — Blue
BN — Brown
OR — Orange
Y — Yellow
GY — Gray
PU — Purple
PK — Pink
LBU — Light Blue
R54
C3
C4
C5
C6
R3
120 K
R55
120 K
R7
R8
R9
C10
C11
C12
R12
R13
50 uv
100 uv
V2
V3
R24
C17
20v AC
X1
T3
PK
Y
C14
C15
C16
R14
R15
R16
R17
200 uv
500 uv
1000 uv
2000 uv
R53
BN
W
R
OR
Bare
R18
R19
R20
R21
R22
R23
R25
C19
R28
R29
C25
C26
C27
R30
C33
Shielded Part of Chassis
C31
RANGE SWITCH
R35
C30'
R34
B1
R36
M1
R37
0-100 μA
Add Calibration Resistor if necessary
Shielded Cable
2000 uv
1000 uv
500 uv
200 uv
100 uv
50 uv
R43
R44
R45
R46
R47
R48
R49
R50
R51
R52
R41
R42
Rear Panel Input Connector
Front Panel Input Connector

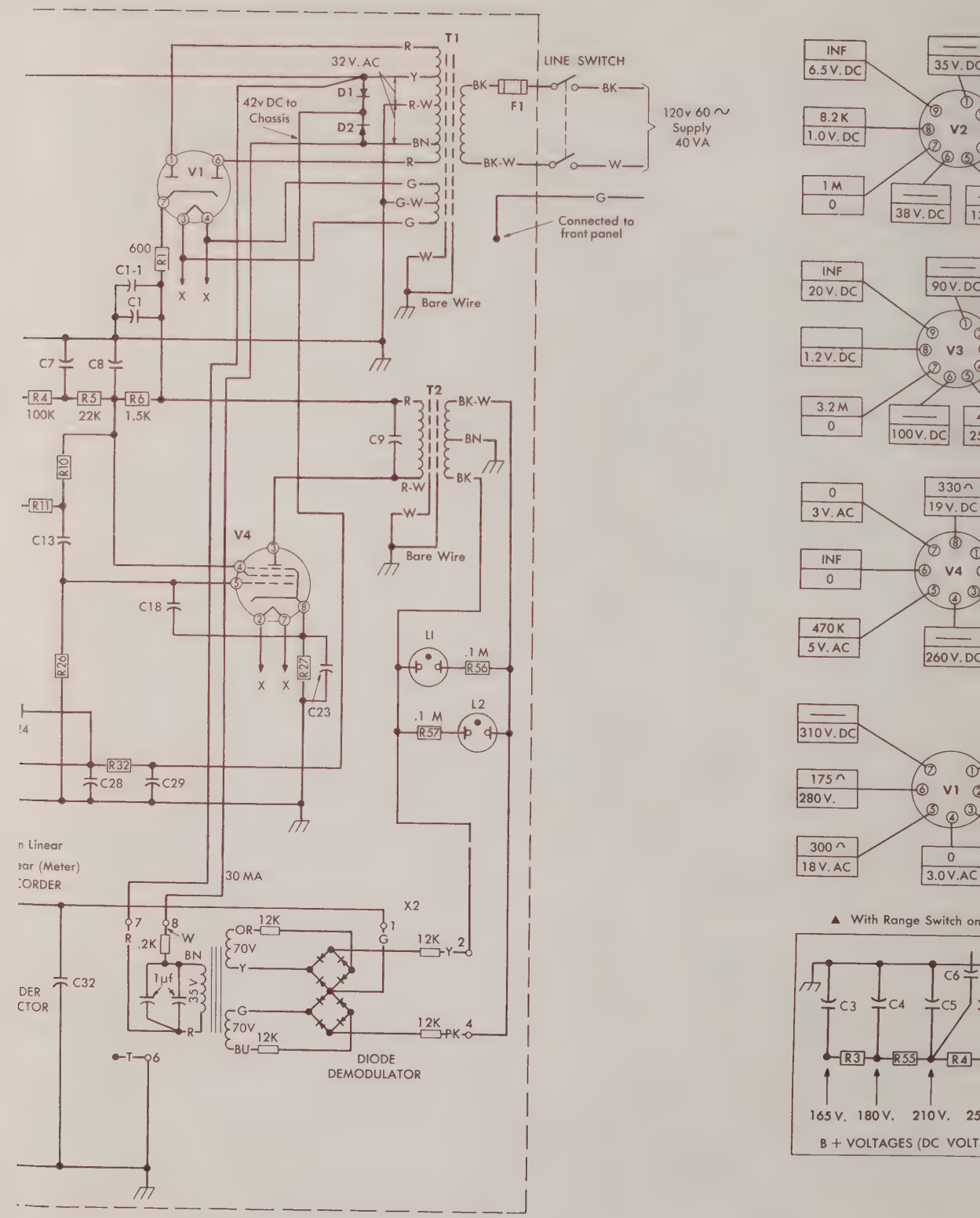
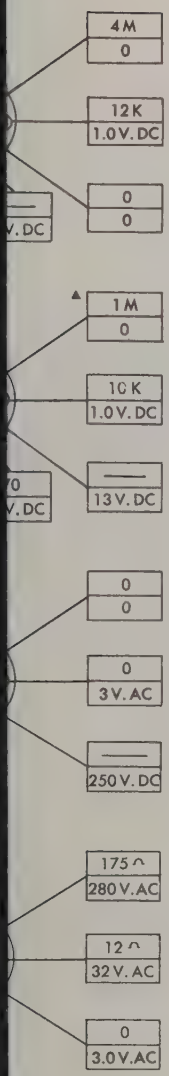
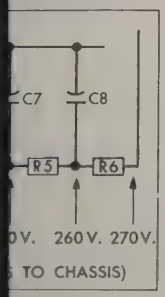


Fig. 5—Voltages, resistances and schematic wiring of 9835 Micromicrovolt Amplifier.



50 microvolts



RESISTORS

				Part No.	Part of
R1	650 Ω	10%	20W	011621	
R3	120K	10%	½W	11-1-0-69	CARD D
R4	100K	10%	½W	11-1-0-68	
R5	22K	10%	½W	11-1-0-60	
R6	1.5K	10%	2W	11-11-0-5	CARD A
R7	1.5M	1%	½W	011516	CARD D
R8	1M	10%	½W	11-1-0-80	CARD D
R9	1M	10%	½W	11-1-0-80	CARD D
R10	1M	10%	½W	11-1-0-80	CARD A
R11	1K	10%	½W	11-1-0-44	
R12	470K	10%	½W	11-1-0-76	SK. 1
R13	240K	5%	½W	11-4-0-145	SK. 1
R14	150K	10%	½W	11-1-0-70	SK. 1
R15	47K	10%	½W	11-1-0-64	SK. 1
R16	24K	10%	½W	11-1-0-108	SK. 1
R17	24K	10%	½W	11-1-0-108	SK. 1
R18	3.9M	10%	½W	11-1-0-87	
R19	12K	10%	½W	11-1-0-57	CARD D
R20	8.2K	10%	½W	11-1-0-55	CARD D
R21	1M	10%	½W	11-1-0-80	CARD D
R22	10K	10%	½W	11-1-0-56	CARD D
R23	8.2K	10%	½W	11-1-0-55	CARD D
R24	2.2M	10%	½W	11-1-0-84	CARD D
R25	1M	10%	½W	11-1-0-80	CARD D
R26	470K	10%	½W	11-1-0-76	
R27	330 Ω	10%	5W	11-12-0-1	
R28	2K	10%	0.1W	10-9-13-6	
R29	2K	10%	0.1W	10-9-13-6	
R30	470 Ω	10%	2W	11-3-0-40	
R32	150 Ω	10%	10W	011622	
R34	2K	10%	0.1W	10-9-13- 6	
R35	980 Ω	.05%	0.1W	10-9-13-18	
R36	68 Ω	10%	½W	11-1-0-30	CARD B
R37	9K	.05%	0.1W	10-9-13-7	CARD B
R41	49.5K	.05%	0.1W	10-21-13-21	CARD B
R42	500 Ω	.05%	0.1W	10-21-13-21	CARD B
R43	500 Ω	.05%	0.1W	10-9-13-12	CARD C
R44	625 Ω	.05%	0.1W	10-9-13-11	CARD C
R45	820 Ω	.05%	0.1W	10-9-13-10	CARD C
R46	905 Ω	.05%	0.1W	10-9-13-9	CARD C
R47	951.25 Ω	.05%	0.1W	10-9-13-8	CARD C
R48	500 Ω	.05%	0.1W	10-9-13-12	CARD C
R49	300 Ω	.05%	0.1W	10-9-13-13	CARD C
R50	100 Ω	.05%	0.1W	10-9-13-14	CARD C
R51	50 Ω	.05%	0.1W	10-9-13-15	CARD C
R52	50 Ω	.05%	0.1W	10-9-13-15	CARD C
R53	20.02 Ω	.05%	0.1W	Std. 3368-T	
R54	910 Ω	10%	½W	11-1-0-106	
R55	120K	10%	½W	11-1-0-69	CARD D
R56	.1M	10%	½W	11-1-0-68	
R57	.1M	10%	½W	11-1-0-68	

CAPACITORS

				Part No.	Part of
C1, C1-1	4 µf	450 v		Std. 2645-52	CARD A
C3	4 µf	450 v		Std. 2645-52	CARD D
C4	4 µf	450 v		Std. 2645-52	CARD D
C5	4 µf	450 v		Std. 2645-52	CARD D
C6	600 µµf			23-1-0-4	
C7	4 µf	450 v		Std. 2645-52	CARD A
C8	4 µf	450 v		Std. 2645-52	CARD A
C9	1 µf	600 v			023046
C10	.05 µf	400 v		23-3-0-9	CARD D
C11	.05 µf	400 v		23-3-0-9	CARD D
C12	.005 µf	600 v		23-3-0-10	CARD D
C13	.1 µf	400 v		23-3-0-8	CARD A
C14	.05 µf	150 v		23-3-0-25	
C15	1000 µµf	300 v		23-1-0-9	
C16	500 µµf	500 v		23-1-0-8	
C17	600 µµf			23-1-0-4	
C18	1000 µµf	300 v		23-1-0-9	
C19	25 µf	1.5 v		23-2-0-8	CARD D
C23	50 µf	25 v		Std. 2645-53	CARD A
C24	600 µµf			23-1-0-4	
C25	8 µf	5 v			023036
C26	8 µf	5 v			023036
C27	8 µf	5 v			023036
C28	250 µf	50 v		23-2-0-15	
C29	250 µf	50 v		23-2-0-15	
C30	600 µµf			23-1-0-4	
C31	600 µµf			23-1-0-4	
C32	2000 µf	15 v		23-2-0-5	
C33	250 µf	50 v		23-2-0-15	

MISCELLANEOUS

			Part No.
B1	Varistor Part of Std. 3368-B-1		Std. 3246-2
T1	Transformer		19-2-0-3
T2	Transformer		019195
T3	Transformer		Std. 1178-42
V1	Tube 6X4		22-3-0-1
V2	Tube 6072		022068
V3	Tube 12AX7		22-1-0-6
V4	Tube 6L6		Std. 3246-178
X1	Converter		Std. 3338-6
X2	Diode Demodulator Converter		057048
D1	Crystal Diode		057028
D2	Crystal Diode		057028
F1	Fuse .6 Amp Slo-Blo		14-5-0-3
M1	Linear Meter		
	For 9835-A	O-Left Scale	021023
	For 9835-B	O-Center Scale	021024

NOTES

1—In socket voltage and resistance chart, upper section of each block gives resistance to chassis; lower section of each block gives voltage to chassis. Voltages and resistances are measured to chassis except as indicated. A dash indicates resistances not measurable.

2—Voltages are d-c except as indicated. These are average values, obtained when 120 volt a-c line voltage is applied to the amplifier.

3—When making voltage measurements the amplifier input should be shorted between chassis and pin 2 of V2. Set the range dial on 2000 microvolts except where noted otherwise.

4—Resistances are measured with tubes removed from sockets.

5—Abbreviations M = megohm
K = thousand ohms
INF = infinite

6—All voltages and resistances have a tolerance of ±10%.

7—All voltages and resistances are measured with a R.C.A. Volt-Ohmyst (20,000 ohms/volt).

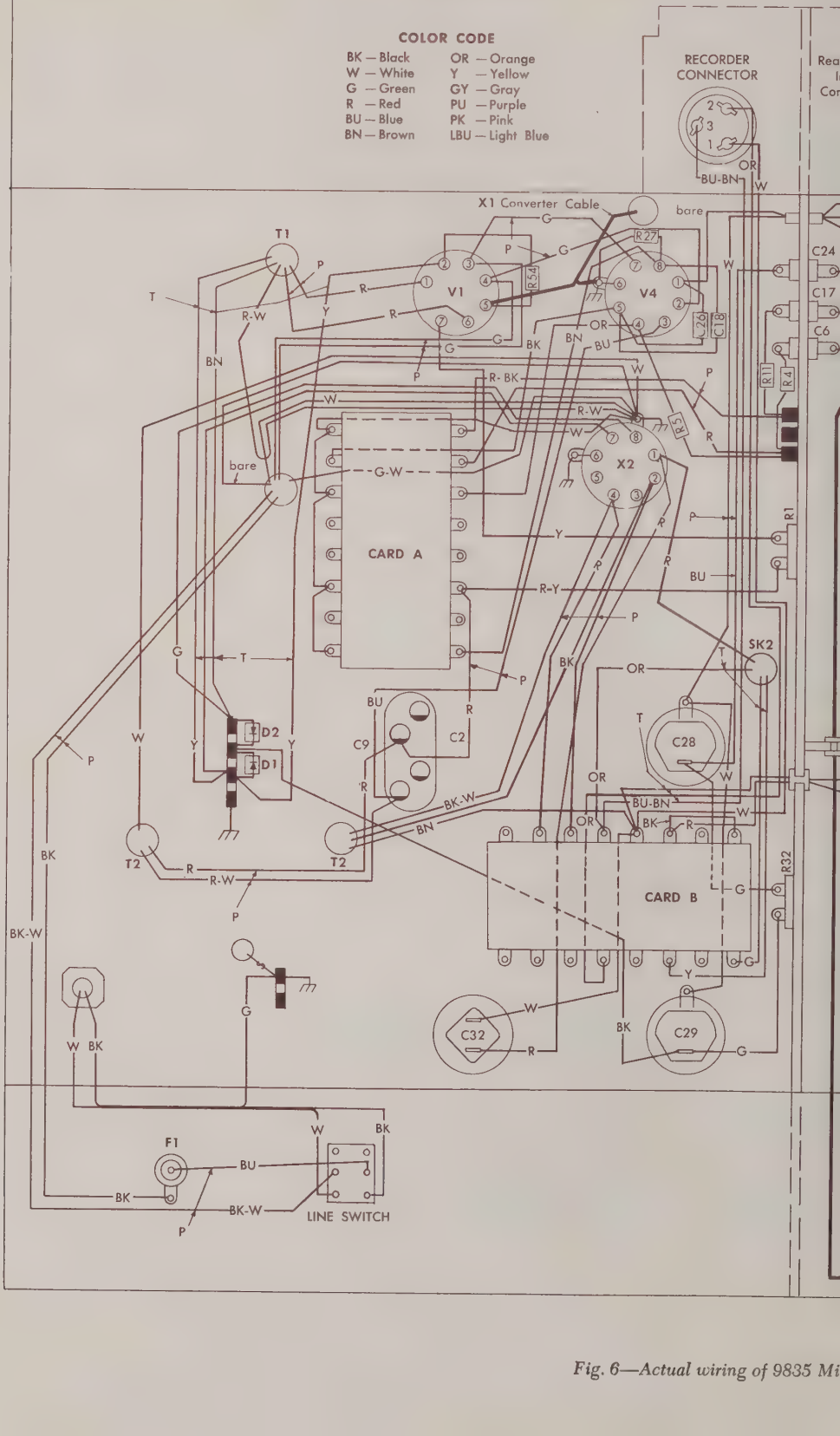
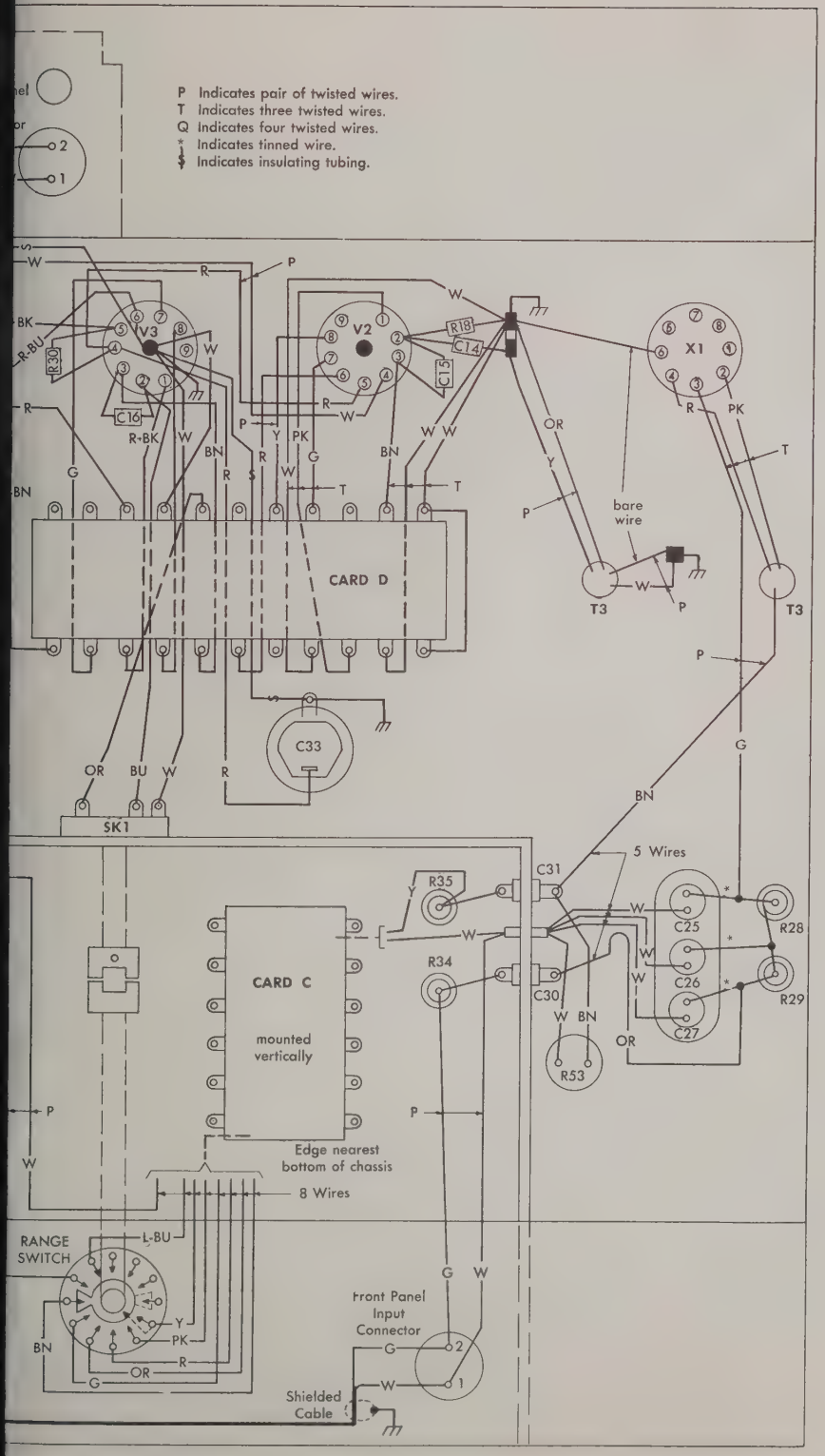


Fig. 6—Actual wiring of 9835 Mi



omicrovolt Amplifier.

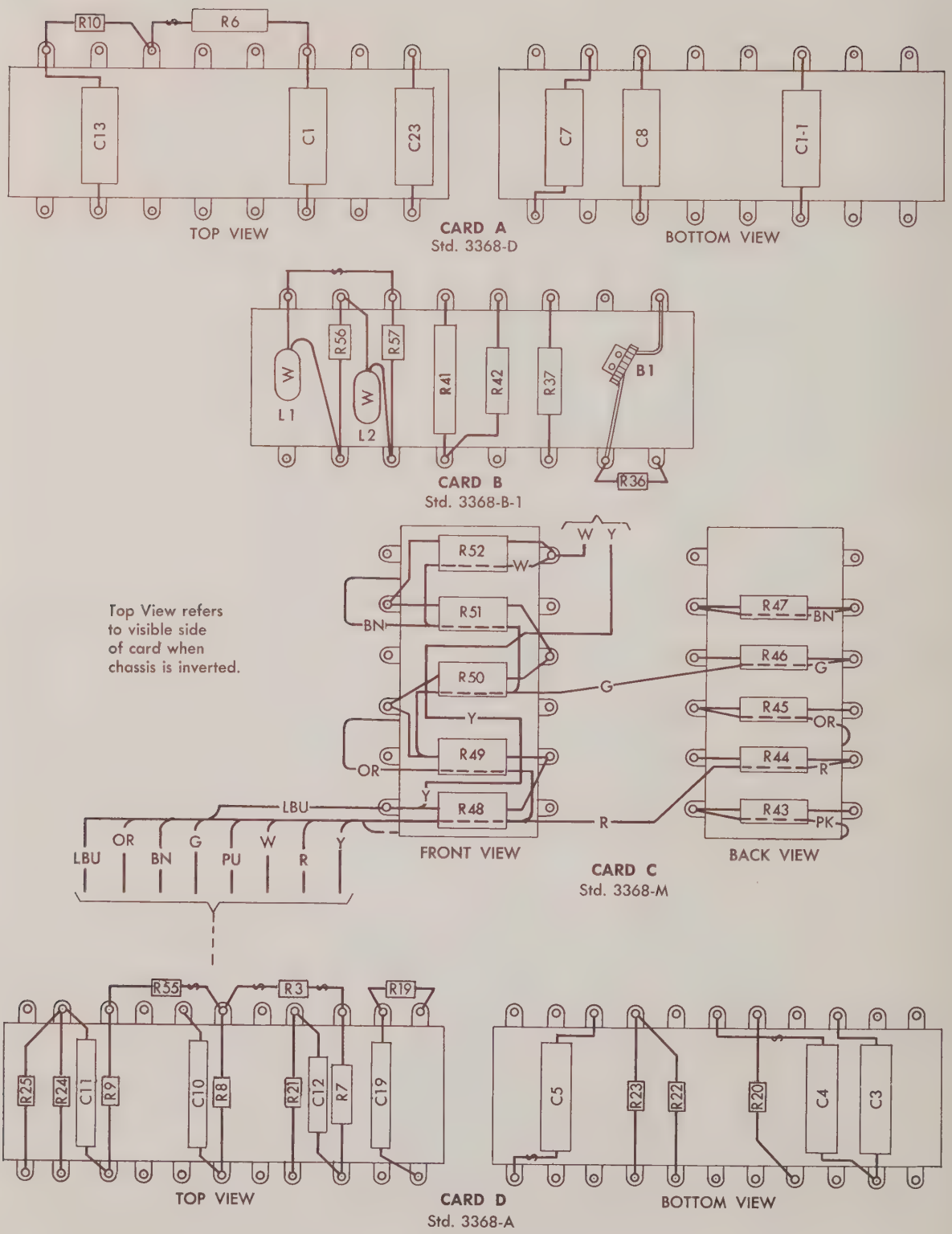


Fig. 7—Components mounted on cards shown in Fig. 6.

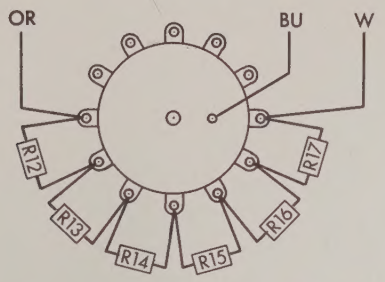


Fig. 8—Range switch wafer located at SK1 in Fig. 6.

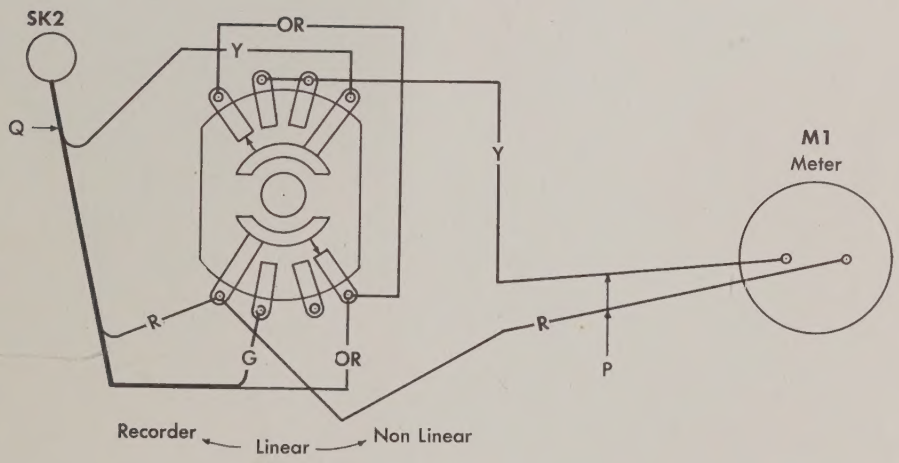


Fig. 9—Switch and meter on front panel. Wires are run through hole in chassis marked SK2 in Fig. 6.

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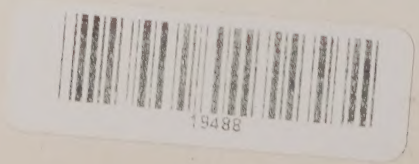

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